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SURFACE PREPARATION AND COATINGS
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HUMAN RESOURCE INNOVATION
MARINE INDUSTRY STANDARDS
WELDING
INDUSTRIAL ENGINEERING
EDUCATION AND TRAINING

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THE NATIONAL SHIPBUILDING RESEARCH PROGRAM

Application of Industrial Engineering Techniques to Reduce Workers' Compensation and Environmental Costs - Deliverable B

U.S. DEPARTMENT OF THE NAVY
CARDEROCK DIVISION,
NAVAL SURFACE WARFARE CENTER

in cooperation with
National Steel and Shipbuilding Company
San Diego, California

Report Documentation Page

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DELIVERABLE B

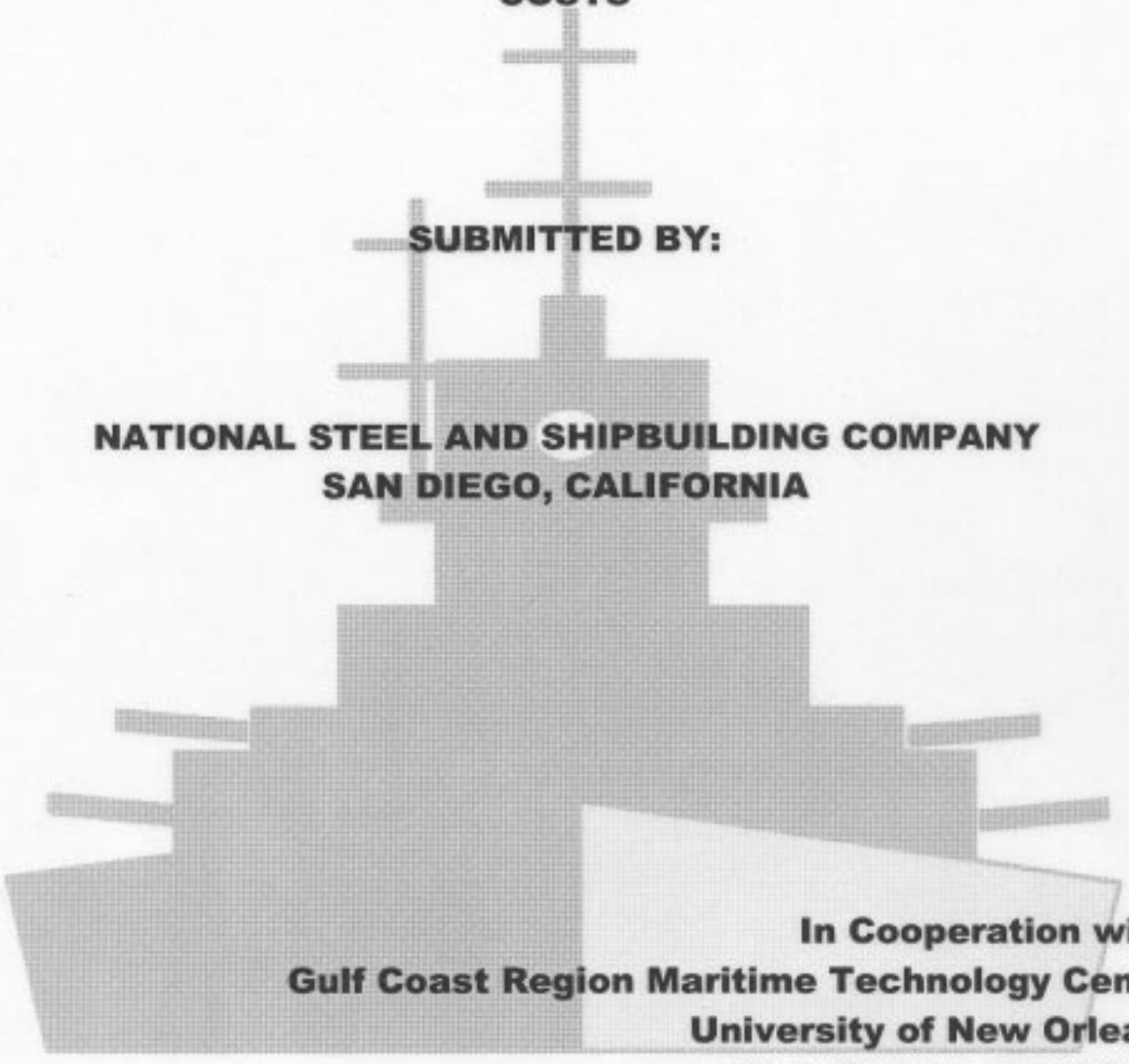
PAINT AND BLAST UPPER EXTREMITY INJURIES

THE NATIONAL SHIPBUILDING RESEARCH PROGRAM

PANEL SP-8 INDUSTRIAL ENGINEERING

Report Number 0526

APPLICATION OF INDUSTRIAL ENGINEERING TECHNIQUES TO REDUCE WORKERS' COMPENSATION AND ENVIRONMENTAL COSTS



SUBMITTED BY:

NATIONAL STEEL AND SHIPBUILDING COMPANY
SAN DIEGO, CALIFORNIA

In Cooperation with:
Gulf Coast Region Maritime Technology Center
University of New Orleans
New Orleans, Louisiana

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SUMMARY

The mechanical cleaning process is a major aspect of the painting process and therefore had to be considered part of the injury prevention process. The actual surface preparation processes were observed in a number of process areas such as, in the On-Block areas, Blast pit operations, Ship board operations, Sub-assembly areas, Sheet metal shops, to determine exposure to power tools. It was noted that according to the skill level of the Painters, techniques in the use of power tools were completely different. The different body positions, in the aspect of how they held the tools to perform mechanical cleaning operation, were interesting, in that, there was no universal technique. The following factors such as, size of the units, areas of difficulty, contour and shape, contorted positioning, etc., were all taken into consideration during the observation period. Due to the nature of work in Blast and Paint, certain positions for mechanical cleaning were unavoidable.

During the observation process, Painters were observed using more 15 degree angles for mechanical cleaning than actually required. When using the standard 15 degree angle for mechanical cleaning, you subject the wrist to pain and injury. When using unnatural wrist positions, it was noted that more pressure was exerted on the hand, arms, elbows, and especially the shoulders. Most of the Painters in the production areas, where mechanical cleaning was performed, were observed using unnatural or cramped positions for mechanical cleaning.

Nearly all Painters use wire wheels to perform SP-3 and SP-11surface preparation requirements. The use of wire wheels posed other problems in regards to injuries, such as wires becoming dislodged from the bristles, and the weight of wire cups.

Another observation noted was the average ages of the Painters and Blasters. **(see appendix, sec.b.chart b-1).** This was noted because age could have been a factor in contributing to the injury rates. The Blasters and Painters injury rates for ages thirty-two to forty-four years were higher. During these years the employees are more mature, but it could be possible that unnecessary risks were taken to perform job functions.**(see appendix, sec. a, charts a-1 to a-3, also sec. b, chart b-1).** It is also of note, that this age group is mentally more mature, their years in Blast and Paint range between one and seven years. **(see appendix, sec.c).**Incidentally this experience level between one and seven years were the most injured group in Paint and Blast.**(see appendix, sec.c)**

Gloves were also examined as possible contributors to hand and finger injuries. During the average production shift, standard issued thin cotton gloves are used for the workers' hand protection. During the winter months, these employees complained that the gloves were not sufficient to protect them from the cold air exhaust of the grinders and buffers. During the normal operation of the these air tools, excess air is released across the operators hand. Another problem noted was, the formation of ice on the tools during winter months. These particular gloves caused the workers' hands to literally become glued to the power tools during the periods when ice formed on the tools. This caused cumulative trauma disorders of the fingers or "white finger syndrome". One final note about these gloves, is that they were of little use for vibration protection for the user.

The final aspect of the observation process included the use of power tools themselves. Before the new requirements and procedures for mechanical cleaning were introduced in Paint and Blast, heavier tools and abrasives were needed to meet surface preparation requirements. When the new processes went into effect, the tools were not modified to meet current needs and therefore using these tools allowed the user to "over perform" mechanical cleaning. It was noted that the old tools, the" cleco brand", weighed and average of seven pounds plus the addition of a wire wheel or cup which added another pound. The weight of these tools posed problem for most of the physically challenged(smaller) operators. Employees using these tools for mechanical cleaning of areas such as, overheads and bulkheads were observed to be having frequent rest breaks, due to fatigue.

BACKGROUND

In 1994 the Paint and Blast department began the transition from blasting A-2 units to mechanical cleaning and painting. Due to this change in processes, the requirements for mechanical cleaning gradually increased. The former process entailed blasting off preconstruction primer and repainting before erection. During this period, NASSCO went exclusively to Nippe Ceramo preconstruction primer. This was approved for usage on the current construction contracts without having to remove it, prior to applying the first coat of the system.

The pre-erected units (A-2's) went directly to the Paint Department upon completion by the outfitting trades. It was during this period, when the injuries began to escalate in the On-block area and Paint department as a whole. The Blasters, because of work shortages, began to be utilized in the On-block (outfitting) area to perform mechanical cleaning. They too began to experience trauma type injuries. Lost time injuries and first aid injuries in regard to cumulative trauma disorders were being frequently diagnosed by the medical department in 1995 and 1996. **(see appendix, see.sec.e, and sec.d, chart d-3)**

The new requirements for surface preparation was a SP-3, which is to remove all loose and unadhering rust and SP-11, which is to remove all traces of rust, whether adhering or loose. The SP-3 and SP-11 standards, which are universal in the marine industry for surface preparation, may not have seemed on the surface as major contributors to hand, wrist, shoulder, elbow and finger injuries. However upon further observation, reviewing injury data and injury investigations, the main causes centered around gloves, power tools and physical conditioning. **(see appendix, sec.d, chart d-2)**

PARTICIPANTS

As a result of escalating injuries and worker compensation costs **(see appendix, sec. j chart j-4)**, Ms. Judie Blakey, Paint and Blast Department Superintendent, formed a Process Improvement Team to combat these issues. As a result of her efforts the following personnel was assembled because of their expertise and knowledge, to solve the workers compensation and injury issues. Everyone in connection with the team, has extensive knowledge of the processes and procedures of the Blast and Paint Department.

To keep the team focused on the goals of the project, a charter was established. The charter stated that, a PIT (Process Improvement Team) was established to study the causes of hand, wrist and arm injuries within stages of construction Three and Five from mechanical cleaning by Blasters and Painters. Solutions will be recommended for implementation through a pilot program. From anticipated positive results of this pilot program a permanent implementation program will go into effect.

Name	Job Title	Department
Andre Dorais	Facilitator	Training
Indy Parra	Production Supervisor	Paint & Blast
Bobby Flores	Production Supervisor	Paint & Blast
Jim Ferguson	Industrial Hygienist	Safety
Arthur Green	Production Supervisor	Paint & Blast
Tony Robinson	Corrosion Control Specialist	Paint & Blast
Mario Cosio	Ass't Superintendent	Paint & Blast
Judie Blakey	Superintendent	Paint & Blast
Jim Paulson	Manager Safety	Safety
Craig Williams	Staff Engineer	Paint & Blast
Manuel Faria	Painter	Paint & Blast
Jorge Hernandez	Working Foreman	Paint & Blast

This team eventually evolved into the current team who consists of:

NAME	JOB TITLE	DEPARTMENT
Freddie Hogan	Staff Engineer	Human Resources
Andre Dorais	Facilitator	Training
Indy Parra	Production Supervisor	Paint &Blast
Bobby Flores	Production Supervisor	Paint & Blast
Arthur Green	Production Supervisor	Paint & Blast
Tony Robinson	Corrosion Control Spec.	Paint & Blast
Carlos Loya	Production Supervisor	Paint & Blast

METHOD

A. BRAINSTORMING

The first meeting entailed setting the team charter, reviewing injury data and First Report Of Injury (FROI's). During that meeting and subsequent meetings following, a list of priorities was established. They came about as a result of brainstorming and filtering twenty three (23) ideas from the group, that met the problem statement. Several ideas were combined that were similar and as a result these were further narrowed down to the following five areas of priority.

1. Proper Gloves

2. Training

3. Tool Modification

4. Job Rotation within stages of construction Three and Five

5. Tool Selection

B. COURSE OF ACTION

After the team developed all priorities by weighted vote, the following course of action was suggested to solve the problem:

a. Commence exercise program within stages three and five for Blasters and Painters.

b. To reduce repetitive motion type injuries in stages Three and Five, rotate personnel to different job assignments.

c. Work with Fisher Safety to design a glove which meets the employees needs of comfort and fit, while at the same time addressing injury prevention

d. Have on order a number of wrist supports for a trial basis.

e. Research vendor information for vortex valves (heats up air prior to tool) for trial basis.

f. Involvement of Cleco Tool Company and other tool vendors to help design or modify tools with ergonomic considerations.

g. Detail study of mechanical cleaning process and potential alternative solutions, i.e. other tools, other cleaning methods.

C. INDUSTRIAL HYGIENIST RECOMMENDATION

The following course of action was recommended by the Team Industrial Hygienist:

1. Training involving pre-work stretching and intra-shift counter stretching: This is inexpensive and can be implemented immediately. Stretching leaders must receive training by Industrial Hygiene.**(see appendix, sec. f)**

2. Proper glove selection: The gloves are relatively inexpensive and can be used almost immediately. This is in his area of expertise and he desired direct input into glove selection.

3. Tool modification including paint container reduction: Five-gallon paint containers could be reduced to 2.5 gallon container. Other material handling improvements could be investigated. This would address one of the issues related to "material handling and related injuries". Tool modifications could take time both to design the modification, to work out the imperfections, and to install the changes.

4. Job rotation that involves two or more job changes per shift and which requires the use of different body postures and muscle groups: This will require management planning, but should not incur any material costs or significant production lost time. The purpose of job rotation for ergonomic relief is to spread the work stress to several major muscle groups over a single work shift. Posture changes and work changes will accomplish this. It is not sound ergonomic practice to institute job rotation that does not provide intra-shift relief from repetitive motion, strength requirements, and same or unchanged posture. Moving an employee to a new exclusive task every week, month, or longer can be harmful to the employee. Muscle groups will lose strength with inactivity and could be injured when the task is resumed several weeks or months later.

5. Tool selection: This the ideal approach if mechanical equipment could be found that could relieve the employee of the musculoskeletal stress of current work. This could be phased in to replace worn out equipment as a means of controlling expenses. Expect this to take time while the equipment is located, tested, and introduced to the work force.

Note: There is very little strength carry over from one muscle group to another so the act of grinding would not be expected to prepare the employee, strength-wise, for any other task.

TRAINING

A. EXERCISE PROGRAM

I. Stretching vs Exercise

Jim Ferguson commenced training with the Painters who were designated to lead group exercises. The employees were taught proper stretching techniques and the difference between exercise vs stretching, in short making the distinction. Stretching is best done when the muscles, tendons, joints, etc. are warm and have good blood flow. These tissues are more pliable or elastic when warm. You can run the risk of tearing or straining these tissues when they are cold and stiff. How do you overcome coldness and stiffness prior to stretching? In anticipation of stretching , move around, get blood flowing , move your arms, legs, and torso without challenging the limits of your range of motion.

It is not intended that this program result in vigorous movement of any type. It is important that individuals learn to "listen" to their bodies and to recognize when it is warning them against performing certain functions and when it is giving them permission to go ahead with an activity.

The body movements are to be gentle in nature. Body movements should be such that each individual gently tests the limits of their flexibility and range of motion with an **easy stretch.** After holding the easy stretch, test the body's willingness to go a fraction of an inch further. Only with the permission of their body should an individual extend the movements that bring an mild discomfort. This extended stretch is called the **developmental stretch.** Remember, the adages of "mind over matter" and "no pain, no gain" do not apply to us when stretching. **(see appendix, sec. f)**

Sensible stretching does not involve any "pumping" or "jerking" movement. We have all seen people do this. Those that do this type of exercise, (above mentioned) are simply using incorrect technique that will result in strains or sprains. If someone in the group has a injury or physical weakness, such as a slipped disc or pulled muscles that is healing or not yet healed; allow him or her to do movements that are light and do not impact on the injury, if the movements are not in contradiction to medical restrictions.

Caution your group about being patient. Caution the group against trying to get back flexibility and range of motion that was lost over many years in just one or two sessions. Flexibility and improved range of motion will come back, given enough time.

II. Stretching Movements

The attachment **(see appendix, sec. f)** shows drawings of those stretching movements recommended by NASSCO's physical therapist and Ergonomics Coordinator. The groups are limited to the exercises illustrated.

The drawings are shaded on those parts of the bodies that people can expect to feel stress. Again, beneficial stretching will impart a slight steady pull on the muscles involved. There should be no pain.

Stretching should be performed in two phases. The first phase is called the easy stretch during which the stretching movement goes as far as comfortable. The second phase is called the developmental stretch during which the stretching movement goes slightly beyond the comfort zone by a fraction of an inch or more. Pain experienced during any of the stretches means you have exceeded your stretch limits for you at this stage in your stretching program. If pain is felt during a stretch, ease off and back to an easy stretch.

B. POWER TOOL TRAINING

In order to properly train and educate all of the Painters in the use of pneumatic tools concerning their safe and unsafe usage, Norton Abrasive Company came in and performed the training. This class also covered the safe and practical use of abrasives too. In order to accommodate all employees in Blast and Paint, the classes were rotated over two days, with the class size on the average of twenty (20) per class. Twenty was chosen because retention rates may be better in smaller classes with fewer distractions. **(see appendix, sec. g, chart g-2)**

I. Topics Covered

Responsibility for proper use of portable grinding machines and wheels:
Machine Builder
Wheel Manufacture
User

Causes of Wheel Breakage
Type I Straight Wheels
Flanges not matched
Outer Flange Omitted

Substitute Flange
Outer Flange Reverse
Type 6 and 11 Cup Wheels
Type 16,17, and 19 cones and plugs
spindle too long
spindle too short
spindle not threaded far enough
flange design

Improper Speeds
slow speed wheels on high machines
High speed operation with low speed machines
lack of speed control
inadequate power

Abusive Operation
grinding on flat side of straight wheels
cramping of straight wheels
hard arching wheels

Careless Handling of Machine
dropping on floor, etc.
use of racks and hooks

Importance of Proper Machine Maintenance

Guards

Safety Standard Requirements
Type 1 wheels
cup wheels
type 27 and 28 wheels

Auxiliary Protection Devices
operator protection
safety guards
safety goggles and face shields
protective clothing

Work Area Protection
Barriers
Exhaust systems
Wheels Reinforcing
Fiberglass and filament reinforcing

Do and Don't Rules For Safe Portable Grinder Operation
The Three G's
guards
Goggles
Gloves

Fiber Discs Back Up Pads
correct size
no disc to disc
good condition
proper mounting

Acceptable Speed
fiber discs can be run at the rated RPM of the back-up pad
always use a back-up with the RPM clearly marked

C. GLOVES

Fisher Safety Company was contacted to provide samples of various gloves for testing. The gloves they provided were neoprene anti-vibratory, leather, reinforced cotton, nylon and rubber. Fishers manufacturer, Safeguard technologies further assisted us in our efforts.

I. <u>Selection Criteria</u>

Waterproof
Cold/Thermal insulation
Long life
Durability
Dexterity
Comfort/fit
Shock Cushioning
Non- slip surface

II. Glove Description

a. The performance combination, (neoprene and leather in three different styles, combines a synthetic leather palm that stands up to work with the warmth and shock absorption of neoprene. The unique palm design provides a secure gripping surface under all angles of stress. The performance combination offers minimum bulk and will not stiffen with wetting and drying**.**

b. The performance neoprene is an all neoprene glove that offers maximum warmth, comfort and pressure distribution. It is preformed into the shape of a flexed hand to minimize the effort required to hold objects. The sure-grip palm keeps the hand from slipping off the tools.

c. The performance neoprene lite combines neoprene and nylon for both shock absorption and unique high flexibility. It offers outstanding wearing comfort, exceptional all-weather insulating protection and extraordinary compression set. The high quality material provides superior abrasion resistance and durability. The worker wearing this glove will be able to grip firmly with its no slip palm.

III. Custom Design

After these gloves were tested in the On-Block area, the evaluation reports filled out by the Painters and Blasters were not favorable for further testing of the standard gloves (described above). Therefore we had Greg Baker from Safeguard Technologies, come in so we could design a glove that would fit our needs.

In the stages of design, we not only included selected criteria but added anti-vibe material to help reduce vibratory type injuries. **(see appendix, sec. h)**

It was at this stage in the design process, that the team enlisted the support of Therapy Specialist. Therapy Specialist is the company sub-contracted by NASSCO's Workers Compensation Department to perform physical therapy on our injured employees, and assist's in our Return to Work Program.

During this meeting with the glove manufacturer, Judi Coulthard, O.T.R, C.H.T, from Therapist Specialist strongly disagreed with him on what type of glove he thought we needed. She then gave essential input on what type of glove that would not only meet or exceed our criteria, but what was best from an ergonomic standpoint. Next an in-

depth discussion on hand safety, wrist supports, and proper glove selection followed. Major problems identified in wearing gloves can be resolved with proper fit. Gloves that are too thick, rigid, or slick may require more hand strength and consequently cause early fatigue. Gloves can interfere with dexterity or decrease circulation. One study reported that "gloves tend to increase the vibration level at low frequencies and decrease at high frequencies". Proper fit could avoid this tendency. Gloves should be selected to match the specific job. They should cover as little area of the hand as necessary to allow maximum effectiveness. They should minimize perspiration and distribute force to avoid pressure areas and not impair circulation or dexterity. Consequently, they should be tested for optimal thickness, flexibility, absorption, and force distribution. A variety of sizes should be available to accommodate the variety of hands.

The use of gloves in the workplace is controversial. Some of the benefits of wearing gloves are low cost of equipment, increased heat protection and increased ability to produce torque. Gloves designed for a specific job can increase performance. To minimize the incidence of trigger finger , padding of tools or hands to decrease forces could prevent neurovascular injuries.

The production team members designed the current glove from an assortment of samples received from the vendor. The final glove is a soft leather glove, double stitched around each finger, with anti-vibe material occupying the first joint of each finger, where the finger joins to the palm. There is no anti-vibe material in the thumb to prevent circulation restriction. The anti-vibe material was trimmed to about one eighth of an inch in thickness and it covers the complete palm area. **(see appendix, sec. g, chart g-1)**

ERGONOMIC DESIGN OF POWER TOOLS

I. <u>Power Tools</u>

It was recommended and noted during observations, that besides the need for new gloves, the power tool design needed to be resolved. From 1995 to 1996, power tool related injuries escalated and were the major contributor to lost time injuries in the Paint and Blast Department.**(see appendix, sec. g chart g-1)**

The most common risk factors of cumulative trauma disorders are repetitiveness, force, mechanical stress, posture, vibration, and temperature. The most important elements of tool design with regards to the human factors are size, shape, texture, ease of operation, shock absorption and weight.

Cumulative trauma disorders that may occur secondarily to poor hand tool design are trigger finger, synovitis, nerve compression, arterial compression, chronic strain, muscle strain, aggravation of arthritis, epicondylitis, vibration trauma, carpal tunnel syndrome and tendinitis.

II. Tool Handle Size and Shape

Tool handle size is an essential consideration in tool design to maximize grip strength, reduce stress and digital tendons, and avoid stress to the first collateral ligament. Considering male and female for a moment, the hand sizes are different. One size does not fit everyone. The smaller female hand with its smaller muscle mass will not tolerate inadequately levered tool handles or inadequate shock absorption. When a handle diameter is too large and the forces are applied at the fingers, the tendon forces can be two to three times greater than when the force is applied at the middle. Conversely, with a small handle, the fingers cannot effectively apply force because of the mechanically disadvantaged, shortened position of the finger flexors. Small handles can also result in muscle overcompensation and strain. This compromised position and its adverse effects are compounded when the wrist is flexed.

Therefore, when applying maximal crimping force, the wrist should be held in approximately Thirty degrees (30) of extension with small joints slightly flexed, thus allowing the extrinsic flexor muscles to work in a mechanically efficient position and in synergy with the intrinsic muscles. A partially stretched muscle will contract more forcefully than an unstretched muscle at the time of firing.

III. Handle Length

The length of the handle should be designed to minimize pressure to the median or ulnar nerve at the distal palm or wrist. It is recommended that handles be a least nine **cm** long to distribute forces evenly. Incorrect size of the handle can cause pressure to underlying tendons, sheaths, and nerves resulting in CTD's such as Trigger Finger, Tenosynovitis, Digital Neuritis, Joint Capsular injury, Carpal Tunnel Syndrome, and Guyon Canal Syndrome.

IV. Tool Contour

Handles should have a small contour to coincide with the curve of the transverse palmer arch and allow for even application of force. On the digital side, the handle should follow the natural palmer curve of the fingers as they flex toward the palm in order to distributed muscle loading evenly to the digits. This curve is contoured to accommodate the natural curve of the ulnar eminence. Short handles do not permit this accommodation and should be avoided or used only when light force is applied. Profiling of handles using digit separators is an

example of poorly designed contour from a biomechanical standpoint. Profiling restricts the range of the hand, impairing comfortable grasp of the tool. The prominence on the handle can cause joint capsule injury, trigger finger, neurovascular injury, or intrinsic strain. Because the neurovascular bundles are superficial on each side of the finger just lateral to the palmer fat pads, they lack protection and are susceptible to direct trauma. The edges of the finger separator on profiled handles can easily compress these structures.

V. Upper Extremity Posture during Tools Use

It is important to assume a correct posture when using tools to prevent shoulder strain, carpal tunnel syndrome, tenosynovitis, or epicondylitis. Tools should be designed so that use does not entail greater than twenty (20) degrees of abduction of the shoulder in the vertical position. Normally this shoulder position will not crate and excessive load. However, abduction greater than twenty (20) degrees increases the amount of shoulder strain.

A heavy hand tool markedly compounds the moment requirement of arm abduction. Research suggests that if shoulder abduction was approximately thirty (30) degrees, muscle fatigue occurred after a period of time three times longer than when abducted sixty (60) degrees, and six times longer than when abducted ninety (90) degrees. The height that is ideals for tall workers may require short workers to turn their wrists or abduct their shoulders.

Holding a tool with the wrist in prolonged ulnar deviation may cause carpal tunnel syndrome. When the wrist is maintained in ulnar deviation, creating ulnar drift of the tendons and tendon sheaths, there is a gradual increase in tenosynovitis, and carpal tunnel syndrome, owing to the altered position of the flexor tendons.

It is important to design the job and the handle so that the wrist is maintained in a neutral position, with the radius aligned with the second metacarpal by adjusting the posture and type of tool, and instruction the employee to keep the wrist straight, malalignment of the wrist is corrected. If the posture cannot be adapted because of the restrictions in design, the tool must be adapted. Job-site evaluations are sometimes needed to evaluate whether a right angle buffer or a pistol shaped sander is more appropriate for the job to be performed with the wrist in a neutral position. The orientation of the work space and location of work pieces relative to the worker's arm are decisive factors.

VI. Hand Tool Texture

Texture of the tool design is an important design consideration. Ergonomic research provided a basis in study to include texture as one of the most important elements of tool design. They found that a handle with a slippery finish or a dry hand requires added strength to retain the tool. If the texture is too coarse, skin irritation and reduce efficiency occur. A correctly textured tool allows for tool retention with minimal energy retention with minimal energy expenditure. Cross cut patterns and resilient rubber are good textures.

Tools must be designed to avoid transmission of shock or vibration to the hand

and upper extremities. Such transmission has been documented to contribute to vibration white finger syndrome, osseous injury, carpal tunnel syndrome, vasoconstriction, and Raynaud's syndrome. Tool vibration may adversely affect the digital arteries, causing permanent injury to the arterial walls.

It is necessary to select work gloves carefully for proper fit and to reduce the tendency for irritant to be embedded in the gloves. Wearing gloves tends to make gripping the tool more difficult. The worker wearing gloves grasps the tool more tightly, resulting in fatigue. Gloves that are too thick, separate the fingers and require oversight gripping. In some situations it may be better to design an energy-absorbing tool that does not require the worker to wear gloves.

The tools should be aligned with the axis of rotation of the wrist, and the tool center of gravity weighted at the middle of the palm in order to reduce rotary forces. The tools or the arm may be supported during use. The hand should be held in a relaxed neutral position, neither oversupinating nor overpronating.

VII. Tool Weight

Tool weight is as important as handle design. Light tools for light tasks is a good rule. Heavier tools can cause intrinsic strain, muscle spasm, tendinitis, and epicondylitis, but also possess adequate inertia to prevent transmission of excessive vibration. An overhead counterbalance, padded arm supports, or both should be considered to reduce the load moment on the shoulder. Tool balancers work by counterbalancing the weight of the tool with a long spring suspended over the work area. These are effective if the work area is limited in size to below the tool balance and the tool is used in one general orientation (vertical or horizontal) but not both.

RECOMMENDATIONS

Using ergonomic design and appropriate selection of hand tools for the prevention of cumulative trauma disorders is paramount. The principles and designs presented should help to reduce the biomechanical stresses on workers hand, arms, and shoulders. Proper tool design and use can improve productively and promote human wellness. In addition, the employer is able to reduce the costs of Workers' Compensation premiums by reducing injuries within the industry.

With the above mentioned criteria in mind, Dynabrade Inc. was chosen as the test company to provide tools. Twelve right angle die grinders and twelve buffers were purchased to accomplished the testing. The Dynabrade tools met the design aspects in regard to ergonomics and these tools are half the weight of the current tools. The tools are of a faster RPM because the less time an employee is mechanical cleaning, the less their chances of injury are. These tools are equipped with composite handles, and front port air exhausts, which will enable the worker to use gloves as an option. Eliminated is the constant icing on the buffers and the bulky handles associated with the Cleco grinders.

We are currently, in the testing stages with other tool manufactures for equipment that meets, competitive price standards, production standards and ergonomic standards. Dynabrade was tested first on the basis, that they provided tools immediately and were flexible with pricing. As other tools are tested and approved, results will be disseminated to the industry via panel meetings, to help reduce Workers Compensation costs.

The concept of wearing anti-vibration gloves while using vibratory hand tools needs further study. A larger sample, a control, a longer trial and additional objective data would improve future studies. Preventive measures need to be instituted in the workplace and therapies for these disorders instituted for the workers. Hand therapist and employers must study the work environment and improve it. All participants must be committed to research. Sound studies are dependent upon meticulous records, complete medical histories, worker production, and minimum absenteeism. The cost of the studies in time and dollars will be far out weighed by savings in production and decreased health care costs.

Appendix

SECTION A

CHART A-1

1994 - 1996 Age Related Injuries (32 - 44 years)

Wrist

Year	Nature of Injury	Years in Trade	Age
1994	Inflammation	3	40
1994	Inflammation	1	26
1995	Inflammation	2	26
1995	Inflammation	16	52
1995	Inflammation	4	29
1995	Sprain / Strain	4	35
1995	Sprain / Strain	16	39
1996	Sprain / Strain	3	44
1996	Sprain / Strain	3 Months	36

CHART A-2
1994 - 1996 Age Related Injuries (32 - 44 years)

Hand

Year	Nature of Injury	Years in Trade	Age
1994	Repeated Trauma	3	45
1994	Inflammation	4	36
1995	Inflammation	2	33
1995	Inflammation	3	44
1995	Inflammation	3	25
1995	Inflammation	3	35
1995	Inflammation	2	33
1995	Inflammation	3	36
1995	Inflammation	2	37
1995	Inflammation	3	39
1995	Inflammation	21	63
1996	Inflammation	1	33
1996	Inflammation	6	35

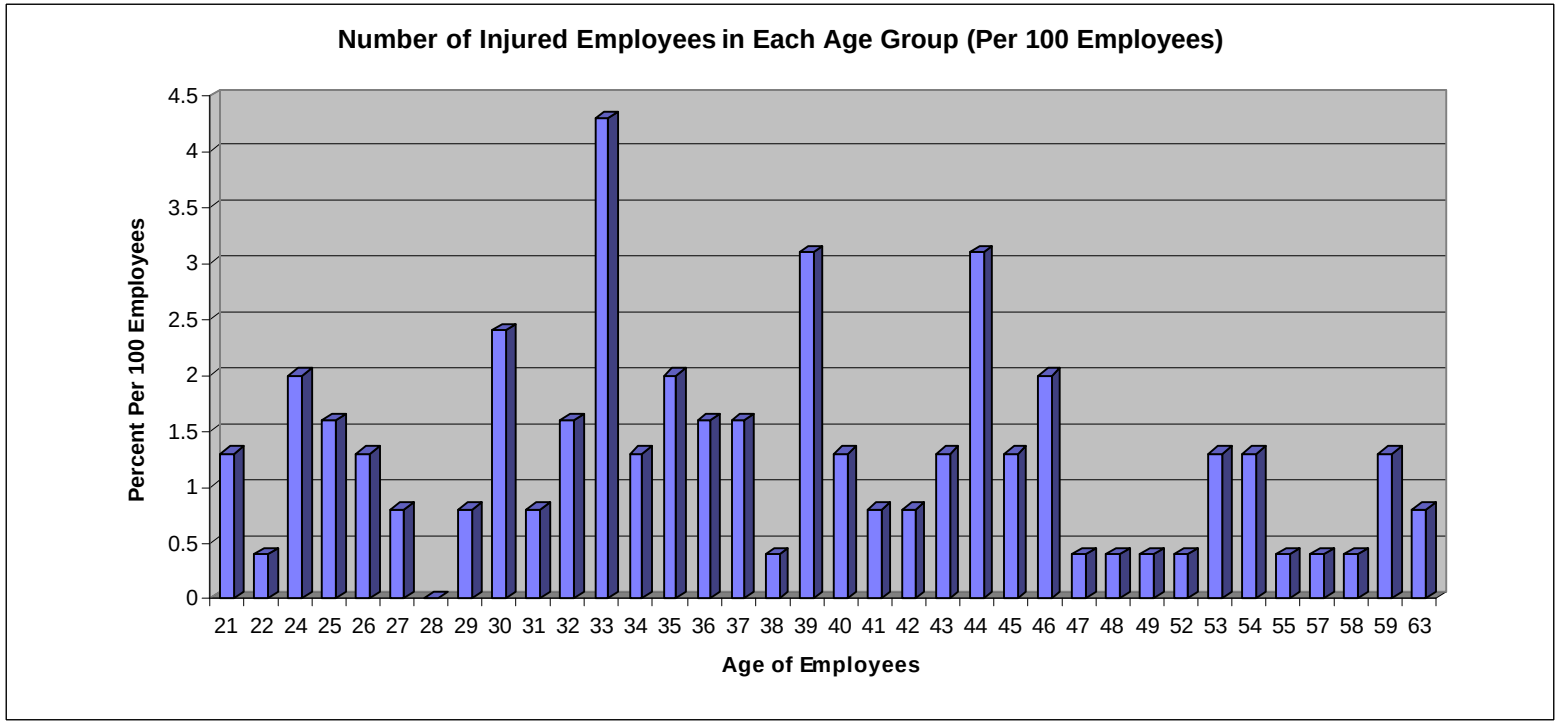
CHART A-3

1994 - 1996 Age Related Injuries (32-44years)

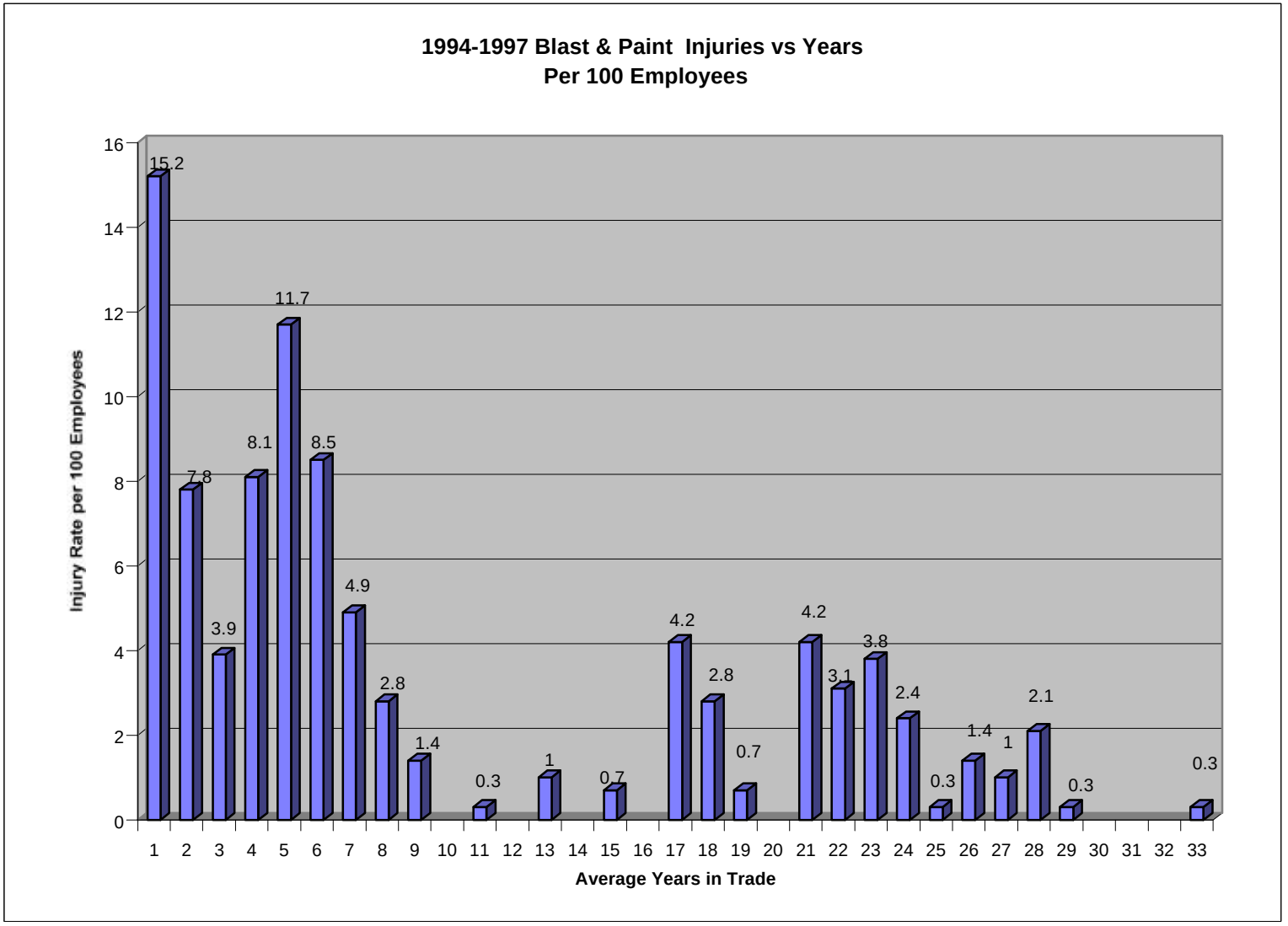
Fingers

Year	Nature of Injury	Years in Trade	Age
1994	Sprain / Strain	4	46
1994	Sprain / Strain	15	44
1994	Fracture	20	46
1994	Strain / Sprain	1	24
1994	Strain / Sprain	1	27
1995	Strain / Sprain	14	40
1996	Fracture	3	33

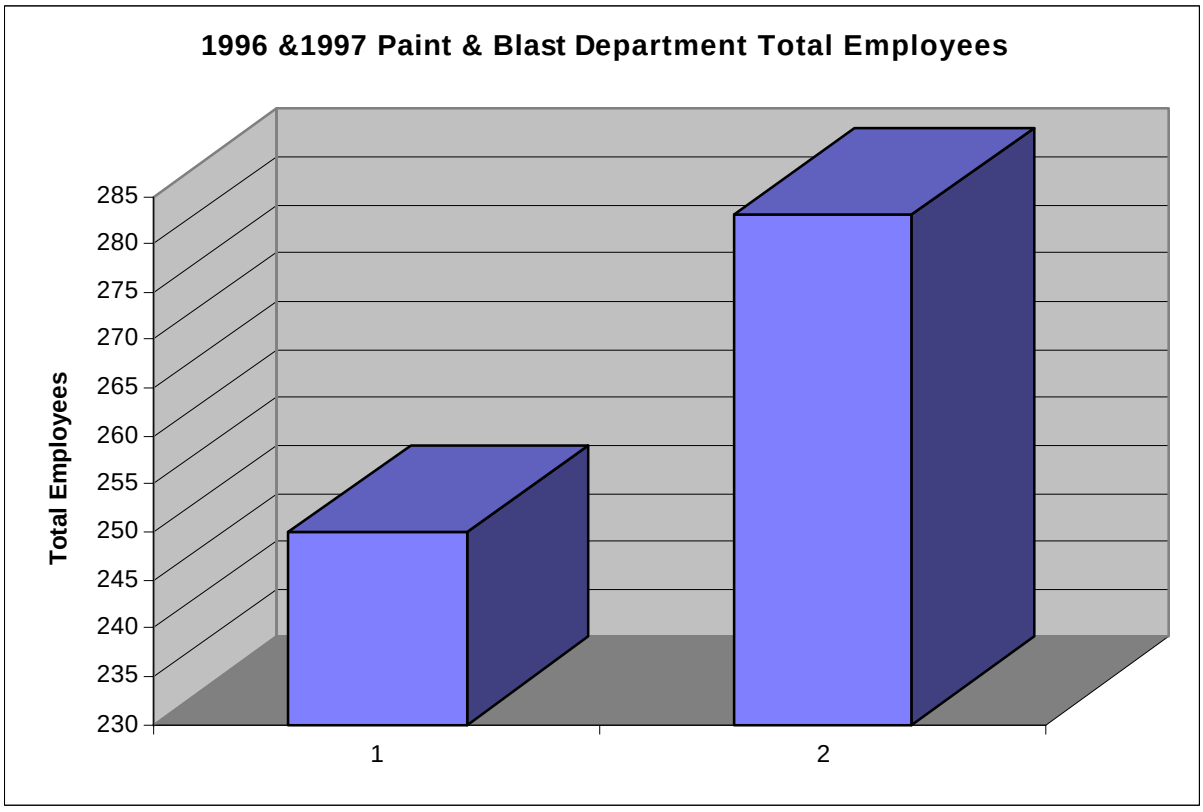
SECTION B

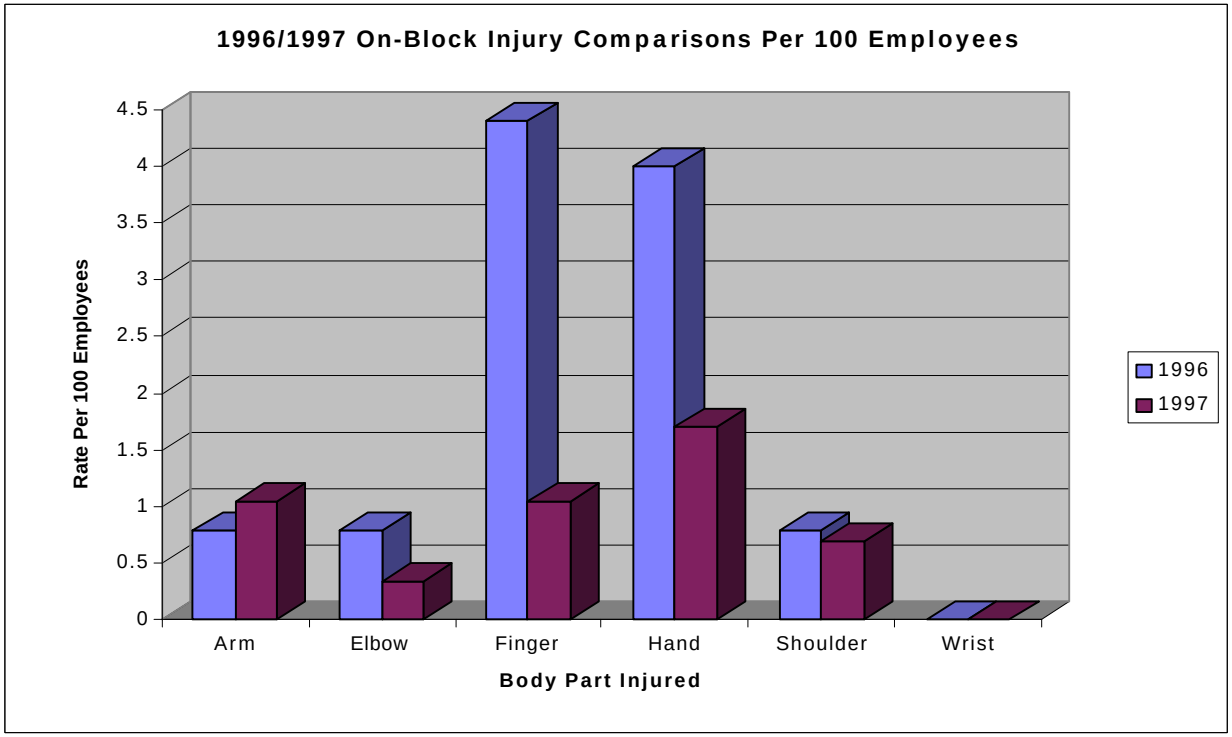

Number of Injured Employees in Each Age Group (Per 100 Employees)
Percent Per 100 Employees
4.5
4
3.5
3
2.5
2
1.5
1
0.5
0
21 22 24 25 26 27 28 29 30 31 32 33 34 35 36 37 38 39 40 41 42 43 44 45 46 47 48 49 52 53 54 55 57 58 59 63
Age of Employees

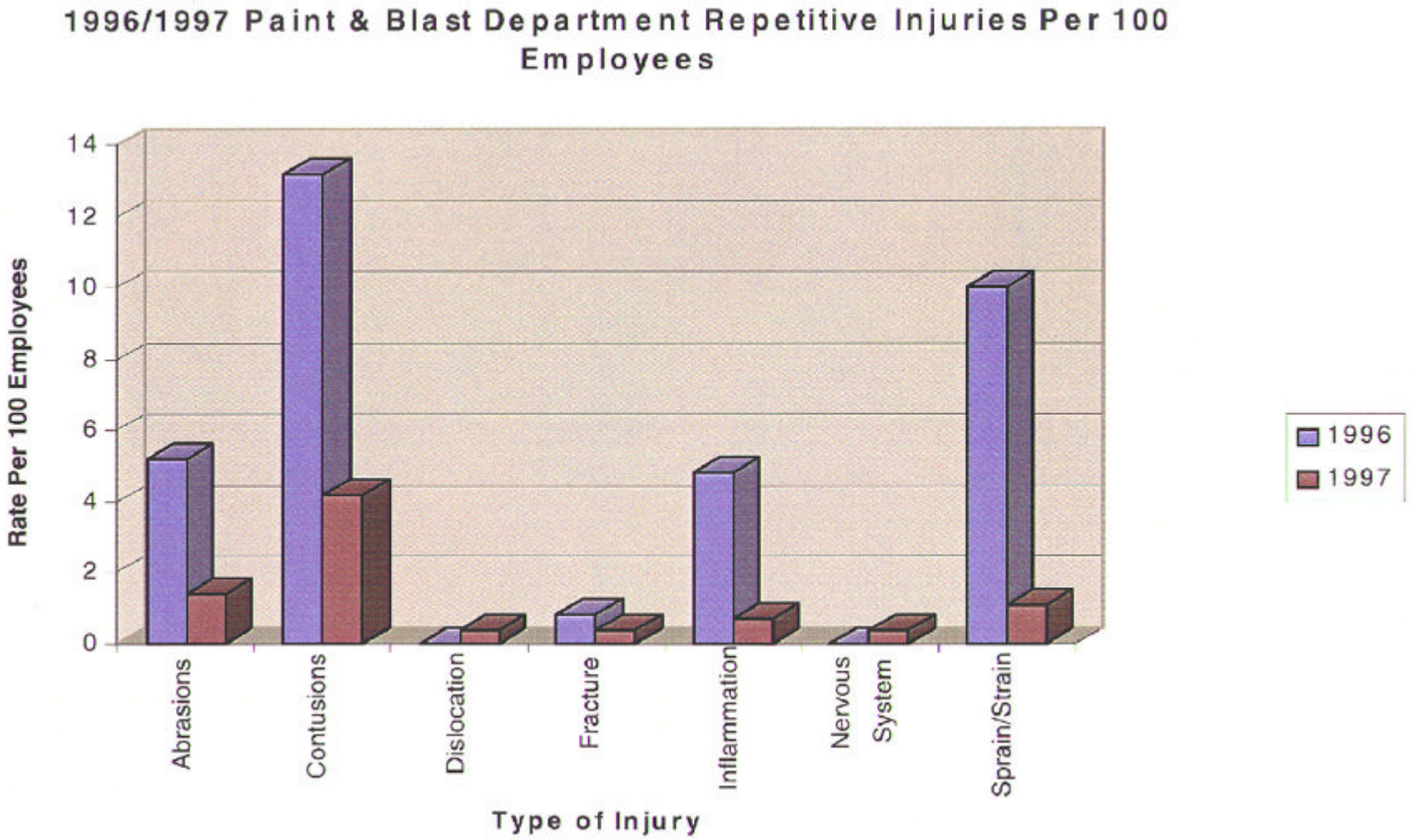
SECTION C

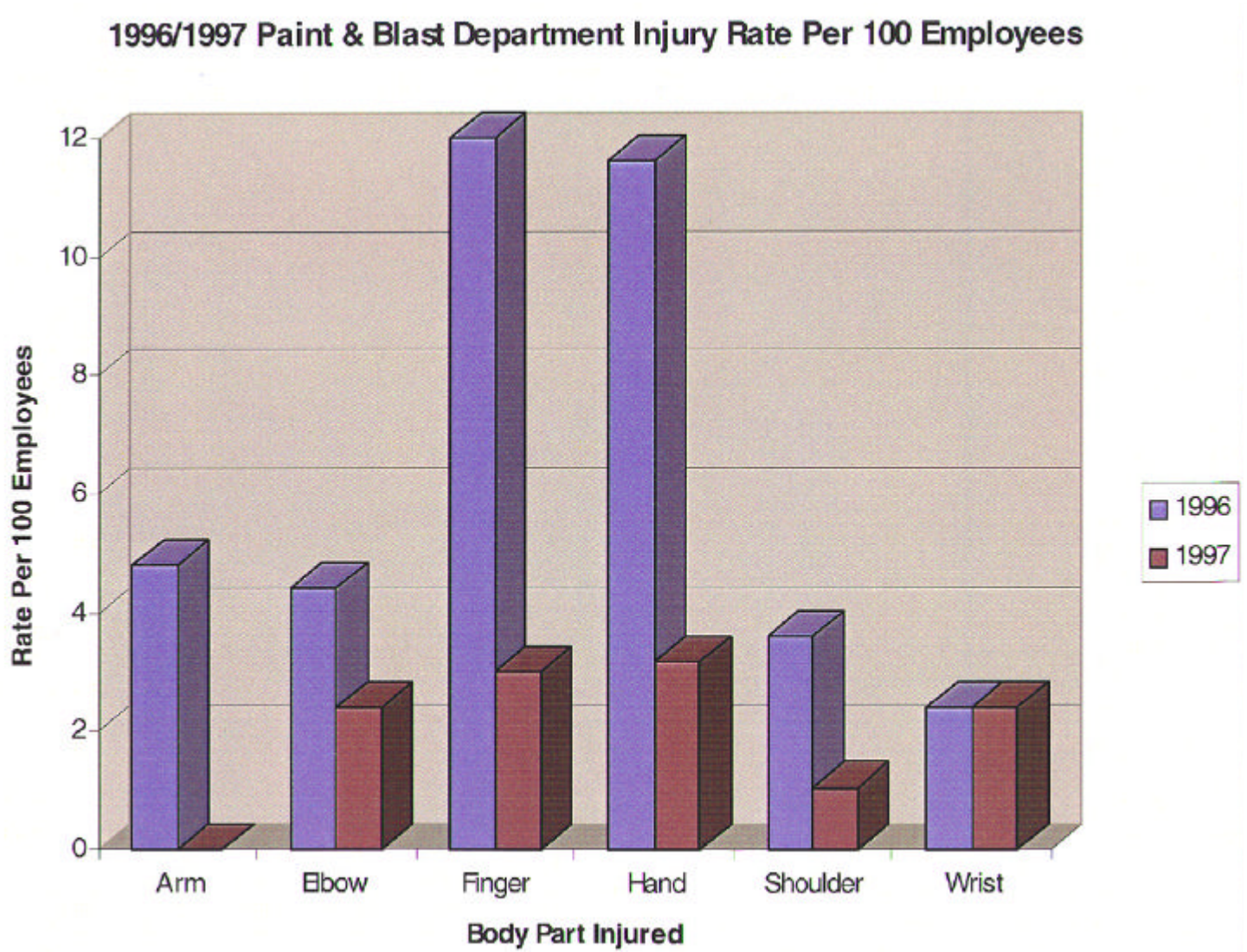

1994-1997 Blast & Paint Injuries vs Years
Per 100 Employees
Injury Rate per 100 Employees
Average Years in Trade
0
2
4
6
8
10
12
14
16
15.2
7.8
3.9
8.1
11.7
8.5
4.9
2.8
1.4
0.3
1
0.7
4.2
2.8
0.7
4.2
3.1
3.8
2.4
0.3
1.4
1
2.1
0.3
0.3
1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24 25 26 27 28 29 30 31 32 33

SECTION D


1996 &1997 Paint & Blast Department Total Employees
Total Employees
285
280
275
270
265
260
255
250
245
240
235
230
1
2


1996/1997 On-Block Injury Comparisons Per 100 Employees
Rate Per 100 Employees
4.5
4
3.5
3
2.5
2
1.5
1
0.5
0
Arm
Elbow
Finger
Hand
Shoulder
Wrist
Body Part Injured
1996
1997


1996/1997 Paint & Blast Department Repetitive Injuries Per 100 Employees
Rate Per 100 Employees
14
12
10
8
6
4
2
0
Abrasions
Contusions
Dislocation
Fracture
Inflammation
Nervous System
Sprain/Strain
Type of Injury
1996
1997


1996/1997 Paint & Blast Department Injury Rate Per 100 Employees
Rate Per 100 Employees
12
10
8
6
4
2
0
Arm
Elbow
Finger
Hand
Shoulder
Wrist
Body Part Injured
1996
1997

SECTION E

Chart E-1

1995 AND 1996 PAINT AND BLAST DEPARTMENT INJURY ANALYSIS

SUMMARY:

1. There were 46 lost time injuries during this time period. Of this number, 29 were injuries to soft tissues of the hands, arms and shoulders; and 17 due to traumas.

    a. Eight of the 46 were sprains, strains, or spasms.

    b. 21 of the 46 were inflammation & tendinitis.

2. Hands (12) were the most commonly injured body part, followed by arms (5) and shoulders (4).

3. Work Activities most affected for the soft tissue injuries:

    10/29 Grinding
    10/29 Material Handling
    5/29 Manual activities not involving mechanical tools, such as solvent wiping etc.
    3/29 Moving about, i.e.. walking, climbing, descend, etc.
    1/29 Grit Blasting

4. 16 Repetitive motions and 11 over exertions total = 27 of the 29 soft tissue injuries.

CONCLUSION:

1. Hands, arms, and shoulder injuries are a major source of lost time injuries in the Paint and Blast Department.

2. Grinding and material handling contribute equally with manual activities second.

3. Repetitive motion is the major cause of injuries with overexertion second.

SECTION F

Stretching Exercises (drawings unavailable)

1 Separate and straighten your fingers until tension of a stretch is felt. Hold for 10 seconds. Relax, then bend your fingers at the knuckles and hold for 10 seconds. Repeat stretch of straightened fingers once more.

2 This stretch may cause people around you to think you are very strange, indeed, but you often find a lot of tension in your face from eye strain. Raise your eyebrows and open your eyes as wide as possible. At the same time, open your mouth to stretch the muscles around your nose and chin and stick your tongue out. Hold this stretch for 5-10 seconds. Caution: if you have clicking or popping noises when opening mouth, check with your dentist before doing this stretch.

3 Shoulder Shrug: Raise the top of your shoulders toward your ears until you feel slight tension in your neck and shoulders. Hold this feeling of tension for 3-5 seconds, then relax your shoulders downward into their normal position. Do this 2-3 times. Good to use at the first signs of tightness or tension in the shoulder and neck area.

4 With fingers interlaced behind head, keep elbows straight out to side with upper body in a good aligned position. Now pull your shoulder blades toward each other to create a feeling of tension through upper back and shoulder blades. Hold this feeling of mild tension for 8-10 seconds, then relax. Do several times. This is good to do when shoulders and upper back are tense or tight.

5 Start with head in a comfortable, aligned position. Slowly tilt head to left side to stretch muscles on side of neck. Hold stretch for 10-20 seconds. Feel a good, even stretch. Do not over stretch. Then tilt head to right side and stretch. Do 2-3 times to each side.

6 From a stable, aligned sitting position, turn your chin toward your left shoulder to create a stretch on the right side of your neck. Hold right stretch tensions for 10-20 seconds. Do each side twice.

7 Gently tilt your head forward to stretch the back of the neck. Hold for 5-10 seconds. Repeat 3-5 times. Hold only tensions that feel good. Do not stretch to the point of pain.

8 Repeat stretch # 3

9 Hold your left arm just above the elbow with the right hand. Now gently pull elbow toward opposite shoulder as you look over your left shoulder. Hold stretch for 15-30 seconds. Do both sides.

10 Interlace fingers, then straighten arms out in front of you. The palms should be facing away from you as you do this stretch. Feel stretch in arms and through the upper part of the back (shoulder blades). Hold stretch for 20-30 seconds. Do at least two times.

11 Interlace fingers then turn palms upwards above our head as you straighten your arms. Think of elongating your arms as you feel a stretch through arms and upper sides of rib cage. Hold for 10-20 seconds. Hold only stretches that feel releasing. Do three times.

12 Hold left elbow with right hand, then gently pull elbow behind head until an easy tension stretch is felt in shoulder or back of upper arm (triceps). Hold easy stretch for 20 seconds. Do not over stretch. Do both sides.

13 Hold onto your lower leg just below the knee. Gently pull bent leg toward your chest. To isolate a stretch in the side of your upper leg, use the right arm to pull bend leg across and toward the opposite shoulder. Hold for 30 seconds at easy stretch tension. Do both sides.

14 A stretch for the side of hip, lower and middle of back. Sit with left leg bent over right leg, then rest elbow or forearm of right arm on the outside of the upper thigh of the left leg. Now apply some controlled, steady pressure toward the right with the elbow or forearm. As you do this, look over your left shoulder to get the stretch feeling. Do both sides. Hold for 15 seconds.

15 The next stretch is done with fingers interlaced behind your back. Slowly turn your elbows inward while straightening your arms. An excellent stretch for shoulders and arms. This is good to do when you find yourself slumping forward from your shoulders. This stretch can be done at any time. Hold for 5-15 seconds. Do twice.

16 To stretch your calf, stand a little ways from a solid support and lean on it with your forearms, your head resting on your hands. Bend one leg and place your foot on the floor in front of you, leaving the other leg straight behind you. Slowly move your hips forward until you feel a stretch in the calf of your straight leg. Be sure to keep the heel of the foot of the straight leg on the floor and your toes pointed straight ahead. Hold an easy stretch for 30 seconds. Do not bounce. Stretch both legs.

SECTION G

Vendor Product Evaluation

Product Name: Date:
Evaluator: Where Evaluated:
User(s): Length of Evaluation:

Category	Description	Y	N	Comments
Convenience	Is the product easy to use?			
Safety	Is the product safe to use?			
Economy	Is the product too expensive to use?			
Simplicity	Is the product unnecessarily complicated?			
Comfort	Is the product uncomfortable to use?			
Durability	Is the product likely to break or malfunction?			
Compatibility	Does the product work with existing equipment or systems?			
Maintainability	Are replacement parts readily available?			
Competition	Does the new product have any advantages over the one being used now?			
Implementation	What changes will the product bring?			
People	What effect will the product have on people?			

CHART G-2

DYNABRADE
BUFFER/GRINDER
STATUS SHEET

DATE _____

NUMBER OF BUFFER	TIME OF USAGE	NUMBER ON GRINDER	TIME OF USAGE	SHIFT	BADGE #

SECTION H

NASSCO
Safety & Prevention Program

Paint & Blast
Process Improvement Team

Therapy Specialists met with your team to discuss the PIT objectives in reducing workplace injury and increasing safety awareness. Safety and prevention, through the combined efforts of employer and rehabilitation professionals, is a concept that many corporations are embracing nationwide.

Therapy Specialists offers the expertise of a medically-based program that will provide the practical experience of clinically working with the types of injuries you sustain and their specific job classifications, and applying that knowledge to a prevention program. We hope to create a partnership with NASSCO by supporting your program with the resources that will make a safe and healthy workplace!

PROGRAM REVIEW

1. PIT actions to date
   - Interaction with glove/tool vendor
   - Safety clips/handouts to promote awareness
   - PIT composition: industrial hygienist/safety/supervisor/management roles
   - Painter trade class injury record (1995 & 1996)

2. Paint & Blast Department Tour
   - View worksite/job tasks
   - Handle tools/gloves utilized in daily activities
   - Brief interview of supervisors

3. Role of Therapist in PIT process
   - Introduction of physical and hand therapist expertise
   - Discuss current treatment program/protocols for Nassco job classes
   - Discuss return-to-work/worksite conditioning concepts

RECOMMENDATIONS

Physical Testing

Your injury data revealed that the individuals sustaining injuries in the painter trade class are, on average, approximately 40 years in age. You also shared that they are typically on the job from one to five years. This has prompted Nassco's HR Department to look at current hiring criteria. It should also serve as an indicator that potential new hires need to be screened to assure that they are physically capable in meeting the demands of their job class. Our recommendation is physical testing be implemented to capture baseline data on specific trade classes and screen potential new hires.

Physical testing could be the most important criteria in impacting the low bac and cumulative trauma injuries. Matching an employee's ability to the essential functions of their job will allow you to eliminate the potential of hiring someone or placing an injured worker back into a job class that is inappropriate for them.

Research into industry methods and trends in injury prevention indicate that implementing systems to match an employee to the physical requirements of a job can be the most effective way to prevent an injury from occurring. As a licensed site for the WorkSTEPS program, Therapy Specialists offers a medically reliable and legally defensible testing program that is ADA and EEOC compliant.

Pre-Employment/Post-Offer Physical Testing
- Four levels of testing available
- Testing is matched to your specific job descriptions

Functional Capacity Evaluations
- Physically measures an injured's ability to return to their job class

Fitness-for-Duty Testing
- Administered to employees who demonstrate difficulty performing essential functions of the job.

Injury Prevention (Generalized or job class specific)
Training for supervisors, work groups, or teams.

Education/Awareness Programs

Topics: Body Mechanics (musculoskeletal review)
Back to basics (back injury prevention)
Postural Stability (cumulative trauma prevention)

Health & Fitness Programs

Topics: Wellness (smoking cessation/healthy diet/exercise/etc)
Stretching & Pacing Throughout the Work Day

Consultation Task Breaks & Task Rotation
Tool/Equipment Modification & Selection
Safety Incentive Program Development
Injury Prevention Data Collection & Review
Ergonomic Worksite Evaluations
Job Analysis

Onsite Services

Transitioning an employee from injury to work expeditiously, can reduce the psychological implications and significant costs associated with disability. These programs coordinate the efforts of employee, supervisor and treating physician, to attain the most effective transition from all levels of injury. The clinician works with the employee in the actual workplace, allowing the clinician to effectively evaluate the employee's limitations and progress them to full recovery.

Injury Treatment
Work Hardening/conditioning on the job
Modified Duty & Light Duty Transitioning

SECTION I

NORTON COMPANY

Kimberly Watson
2355 San Ramon Valley Blvd.
San Ramon, CA 94583-1607
Phone: 619-930-9464
Fax: 619-930-9465
Voice-Mail: 800-826-0455 x3572

Attn-. Fred Hogan
Tony Robinson
Judie Blakey
Craig Williams

Ref Norton Test on AVOS

Dear Team:

I would like to begin by offering my sincere appreciation for allowing me the opportunity to test our new product, AVOS, at your facility. Recently NASSCO has voiced some concerns about safety and grinding techniques in the paint and blast department. As a result, I have made some recommendations to help address your concerns. The following is what we have found:

Test 1 - AO-243

Procedure:

1. Grind all weld seams with AVOS F226 36 grit 4-1/2 inch. Create appropriate profile for quality control.
2. Spot check weld seams for any additional cleaning. Use AVOS Bear-Tex coarse grit 4-1/2 inch to clean any missed grooves or divots.

Number of grinders used:
2
Time:
Test began at 8:00 am
Clean up before paint began at 10-40
Total grind for weld seams- I hr 50 min.
Material Used: 6 grit
4 AVOS F226 3
1 AVOS Bear-Tex Coarse
Amount of material to be ground:
2117 linear inches of weld seam

Test 2 - AO-244

Procedure:

1. Clean weld seams with 4-1/2 inch wirewheel
2. Clean weld seams with 7 inch 3M clean & strip pad
3. Create profile on weld seams with 7 inch fiber disc 36 grit.

Number of Grinders Used:

3

Time:

Test began at 7-30 A.M.

Clean up for paint began at 10 - 5 0 A.M.

Material Used.

3 wire wheels (simultaneously)

3 Clean & strip pads (simultaneously)

3 Fiber discs 36 grit (Totally consumed)

Amount of material to be ground

1578 linear inches of weld seam

Conclusions:

Although the total preparation time & material cost was less with the Norton process as is evident from the data, I would like to point out some key factors separate from labor and material costs.

First, the weight of wire wheel brushes is sigruificantly more than that of the AVOS product. This makes if more difficult for the operator to control the tool and creates additional strain on the wrist muscles. In addition, small pieces of wire release from the wheel while grinding at a rate of 13,000 RPM and can embed in clothing and any exposed skin. This is not a problem with the AVOS products. Quality control voiced concerns over the profile left by a wire wheel. It is not acceptable. However,
the profile is acceptable with AVOS. Wire wheel brushes can not create a distinct edge along side the weld seam and for that matter neither can the fiber discs used at NASSCO. On the other hand, the AVOS product has no problems grinding an edge. This eliminates any need for using a needle gun along the weld seams which is currently required.

Secondly, the back up pad for the AVOS product is much lighter than the seven inch rubber back up pad currently used in the paint and blast department. The lighter product is easier to use and reduces the amount of muscle fatigue experienced by operators. Furthermore, AVOS is designed to be used at a 5-10 degree angle versus NA ;SQ14ber discs which require a 30-45 degree angle. Again, we are reducing the possibility of injury and fatigue. When grinding overhead the spark stream is sweeping away from the operator where as traditional fiber discs sparks fall on the operator's face. Most importantly, the operator can see through the AVOS product and therefore hold the grinder at a much more comfortable angle.

Finally, as seen in the data, the AVOS product did more work on more material than the NASSCO fiber disc and lasted longer. We were able to eliminate the use of a wire wheel and clean and strip pad. The profile achieved with the AVOS product was more acceptable than that done in the traditional NASSCO process. The AVOS product alone, out performed the current fiber. disc. Therefore, even if

the paint & blast department where to maintain the current process, Norton can still provide a cost savings using AVOS fiber discs versus NASSCO fiber disc.

I look forward to continuing to help NASSCO improve on its current processes. We are scheduled to present a safety seminar on the 21st and 22nd of May. I hope you find that Norton is committed to addressing all of NASSCO's needs.

Sincerely,

7

Kimberly Watson
Sales Representative
Norton Co.

cc- Cris Ferregur

SECTION J

CHART J-1

1997 Blast and Paint Department Actual Cost Analysis

Injury Type	**Number of Injuries**	**Average Cost**	**Total**
Arm	3	$24,246.33	**$72,739.00**
Elbow	5	$10,514.00	**$52,570.00**
Finger	9	$5,217.55	**$46,958.00**
Hand	4	$54,964.50	**$219,858.00**
Shoulder	6	$23,877.50	**$143,265.00**
Wrist	3	$5,269.00	**$15,807.00**
TOTAL			**$551,197.00**

CHART J-2

1997 Workers Compensation Cost Comparison to 1996

Body Part	1996 Injuries	1997 Injuries	1996 Rate	1997 Rate	Diff (-) '96 Rate	'96 Per Injury Total	Total Savings
Arm	13	3	14.7	3.4	11.3	$21,870.72	**$243,870.72**
Elbow	11	5	12.4	5.6	6.8	$16,632.99	**$113,104.33**
Finger	30	9	33.9	10.1	23.8	$6,397.77	**$152,266.93**
Hand	29	4	32.8	4.5	28.3	$20,945.10	**$592,746.33**
Shoulder	9	6	10.1	6.8	3.3	$14,298.67	**$47,185.61**
Wrist	7	3	7.9	3.4	4.5	$12,055.08	**$54,247.86**
TOTAL							**$1,203,421.78**

Note: 1. Rates obtained by 283/250=1.132 x Each Year Number of Injuries
2. Based on 1997 & 1996 Head Counts
3. 1996 Rates Restated based on Frequency Rates

CHART J-3

PAINT DEPARTMENT CLAIMS COSTS BY YEAR FOR HAND, WRIST AND ELBOW			
Year	1994	1995	1996
Number of Claims	12	15	12
Total Est. Cost	$239,893	$272,797	$201,169
Cost per Claim	$19,991	$18,186	$16,764

CHART J-4

TOTAL ACTUAL COST INCURRED FROM JULY 1995 TO JUNE 1996 (SHOULDER AND FINGER NOT INCLUDED)	
Painter Helper	$4,493
Abrasive Blaster	$227,488
Painter	$942,260
TOTAL	**$1,174,241**

CHART J-5

1996 BLAST AND PAINT DEPARTMENT COST ANALYSIS			
INJURY TYPE	**NO. OF INJURIES**	**AVERAGE COST**	**TOTAL**
Arm	13	$21,581.48	$280,559.24
Elbow	11	$16,632.90	$182,962.89
Finger	30	$6,397.77	$191,933.10
Hand	29	$20,945.10	$607,407.90
Shoulder	9	$14,298.67	$128,688.03
Wrist	7	$12,056.51	$84,395.57
TOTAL			**$1,475,946.73**

SECTION K

CHART K-1

Injury Rate of Body Parts injured in the Blast and Paint Department (Per 100 Employees)

YEAR	1996	1997
Blast & Paint Employees	**255**	**287**
Number of Injuries	**96**	**35**
Injury Rate/ Per 100	**38%**	**12%**
Rate Reduction		**68%**

CHART K-2

Repetitive Motion Injury Rates

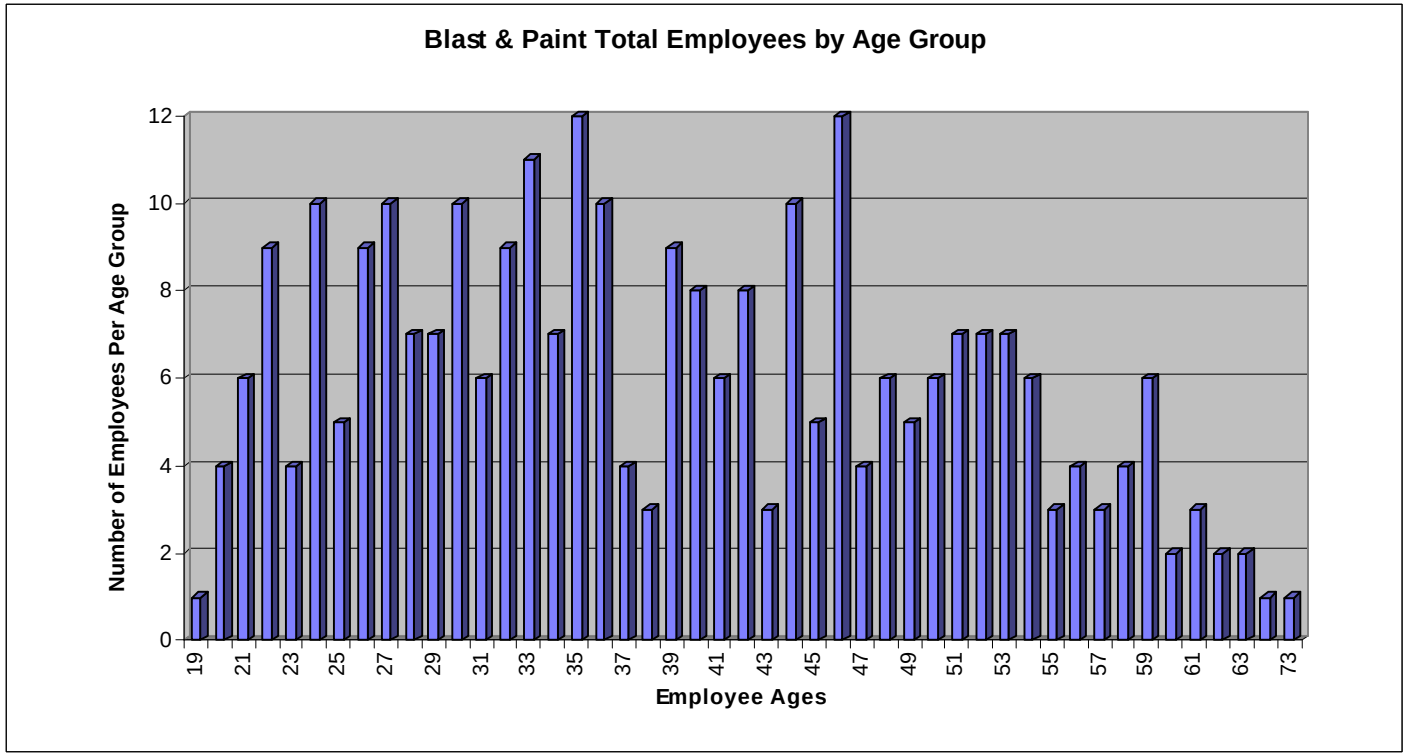
Number of Injuries	**37**	**6**
Injury Rate/ Per 100	15%	2%
Rate Reduction		**87%**

CHART K-3

On-Block Injury Rate

Number of Injuries	**27**	**14**
Injury Rate / Per 100	**11%**	**5%**
Rate Reduction		**55%**

Section L


Blast & Paint Total Employees by Age Group
Number of Employees Per Age Group
0
2
4
6
8
10
12
19
21
23
25
27
29
31
33
35
37
39
41
43
45
47
49
51
53
55
57
59
61
63
73
Employee Ages